



# Electroplate Alternatives to Hard Chrome: Nanocrystalline Metals and Alloys

Paco Gonzalez  
Integran Technologies Inc.  
[gonzalez@integran.com](mailto:gonzalez@integran.com)

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# About Integran

## Background

- Pioneer in microstructurally engineered metals
- Nanostructure alloys - Enhanced durability, strength, wear resistant
- Coatings, CFRP/composite tools/parts, and functional hybrid polymer-nanometal parts for aerospace and automotive

## Intellectual Property

- Over 100 patents on production of metallurgical nanostructures
- First nanomaterial technology patent ever issued

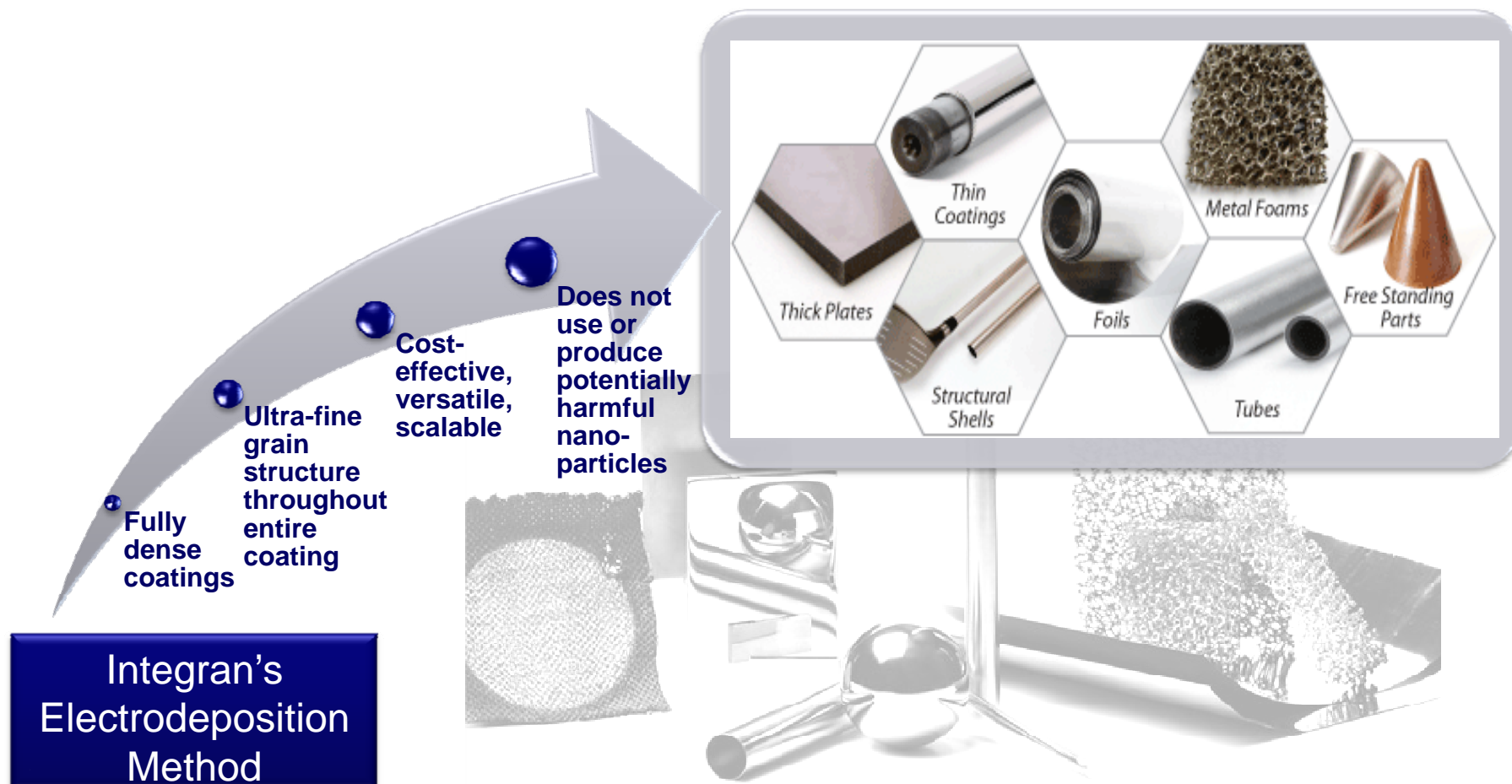
## Facilities

- Applications company - Facilities and partnerships in Toronto, Canada, Pittsburgh, PA USA, and Carlsbad, CA and Tijuana, Mexico.



# Production Process

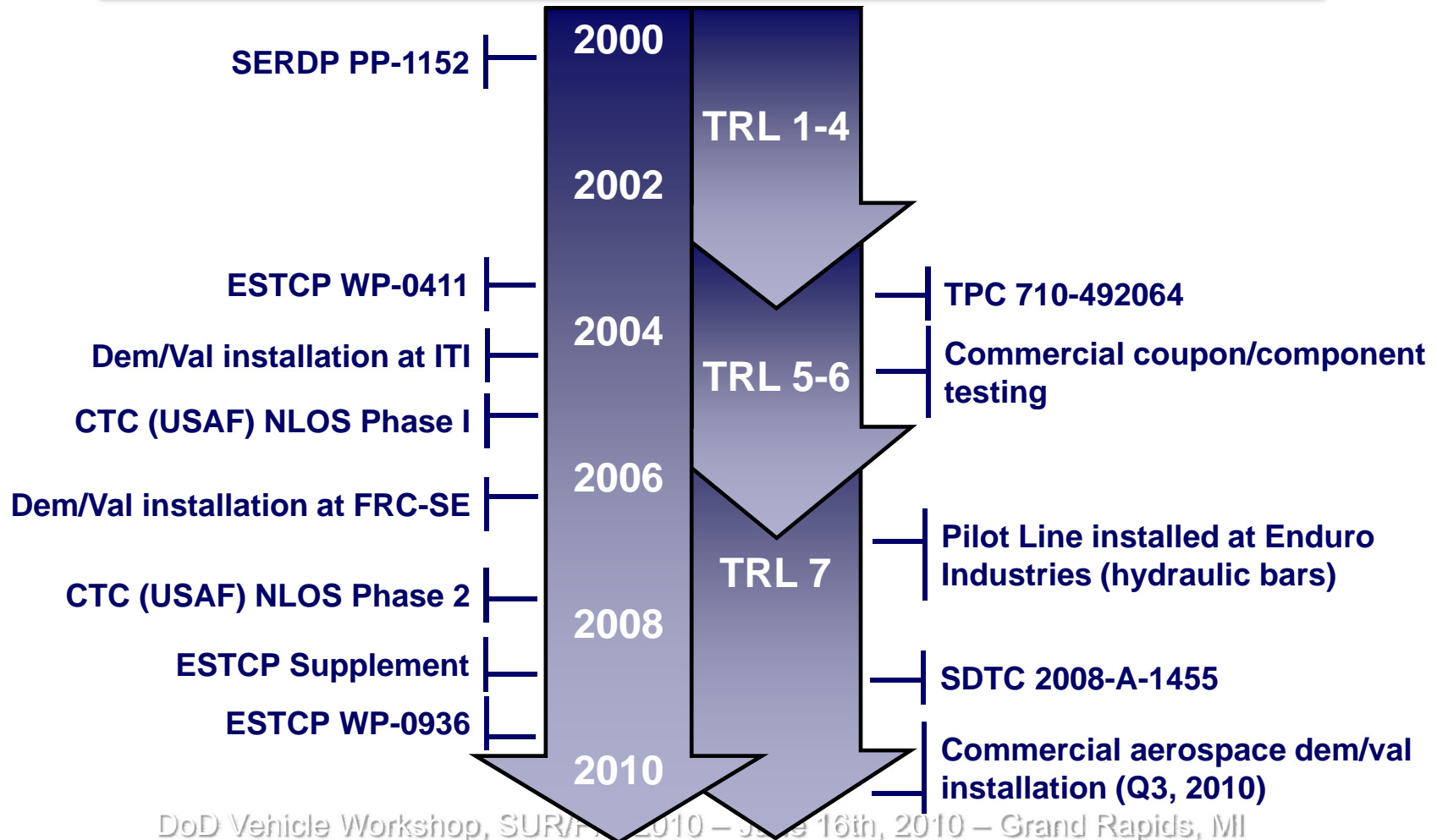
Patented pulsed current electrodeposition process provides a cost-effective, versatile synthesis method to produce high quality nanocrystalline metals and alloys



# Hard Chrome Alternative

## Nanovate™ CR nanocrystalline cobalt alloy

- Developed and demonstrated at the lab scale
- Scaled up to industrial production & moved to DoD depot





## Process (at TRL 7)

### Nanovate™ CR provides significant process improvements over chrome

- Environmentally compliant
- High deposition rate
- High current efficiency
- Drop-in technology
- Excellent bath stability
- JAX, Enduro, SDTC–DemVal Aerospace

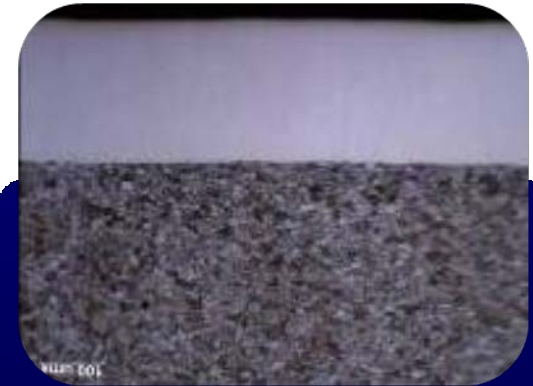


	<b>Nanovate™ CR</b>	<b>Hard Chrome</b>
<b>Deposition Method</b>	Electrodeposition	Electrodeposition
<b>Applicable Geometries</b>	LOS and NLOS	LOS and NLOS
<b>Efficiency</b>	85-95%	15-35%
<b>Deposition Rate</b>	50 – 200 $\mu\text{m}$ per hour	12 – 25 $\mu\text{m}$ per hour
<b>Emission Analysis</b>	Below OSHA limits	Cr <sup>+6</sup>

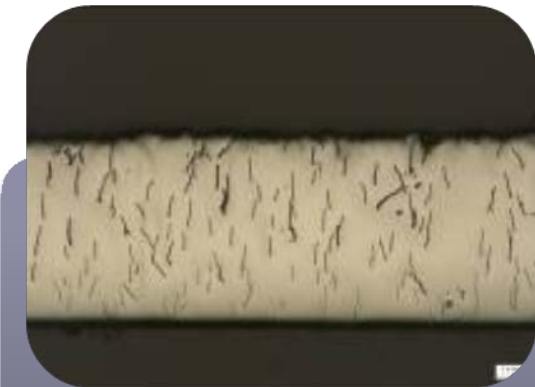
# Properties

**Nanovate™ CR reduces friction, enhances wear & corrosion resistance**

	Nanovate™ CR	Hard Chrome
<b>Appearance</b>	Free of pits, pores & cracks	Microcracked
<b>Hardness (VHN)</b>	530 – 680	Min. 600
<b>Wear volume loss (10<sup>-6</sup> mm<sup>3</sup>/Nm)</b>	6 – 7	9 – 11
<b>Coefficient of Friction</b>	0.4 - 0.5	0.7
<b>Corrosion Resistance (1000 h)</b>	Protection Rating 8	Protection Rating 2
<b>Hydrogen Embrittlement</b>	Pass with bake	Pass with bake

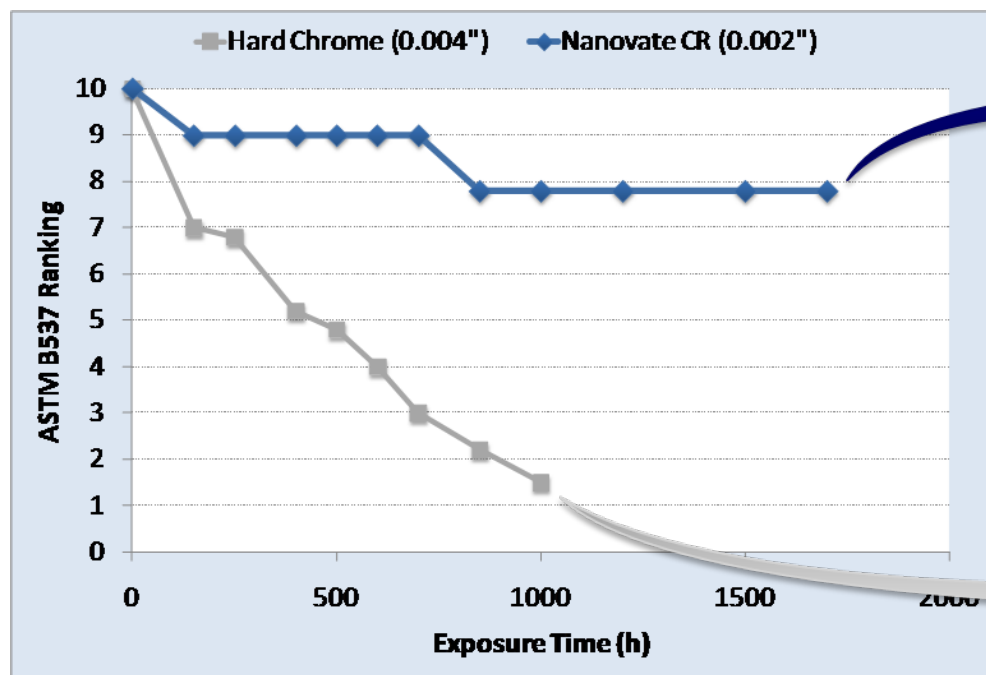


**Nanovate™ CR**  
Pit, pore and crack-free

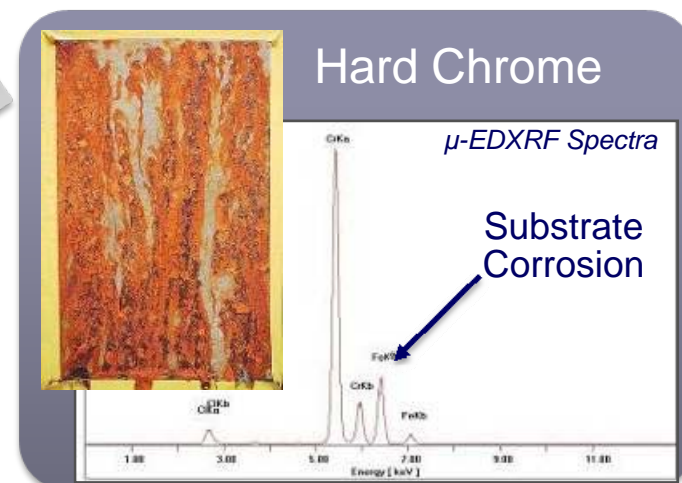
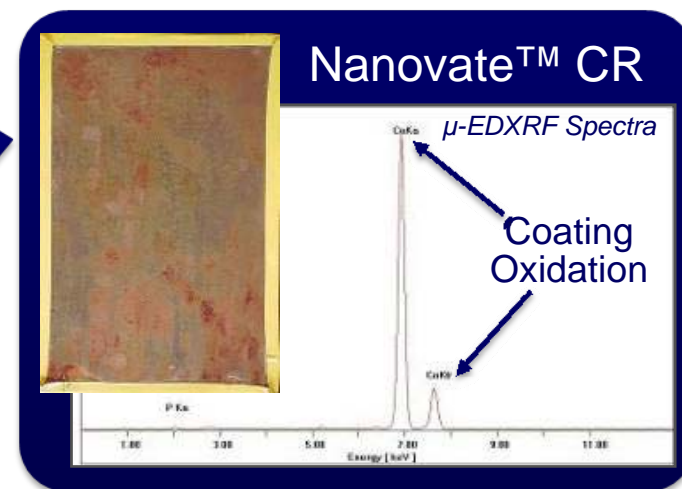


**Hard Chrome**  
Microcracked

## Nanovate™ CR provides enhanced corrosion protection

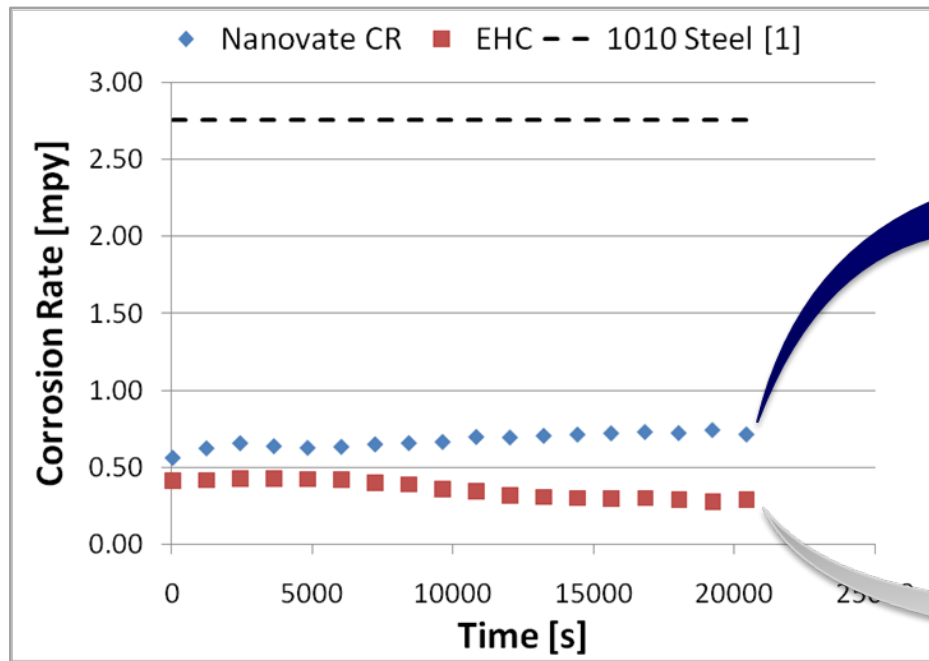


**ASTM B537 Ranking following 1000h  
ASTM B117 Salt Spray**





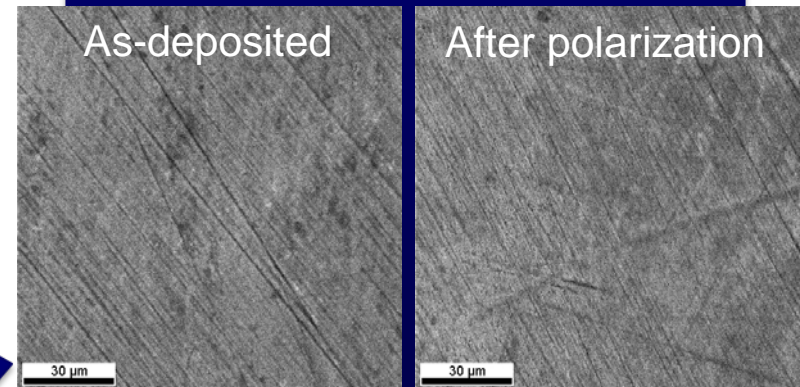
## Nanovate™ CR provides corrosion protection in aqueous environments



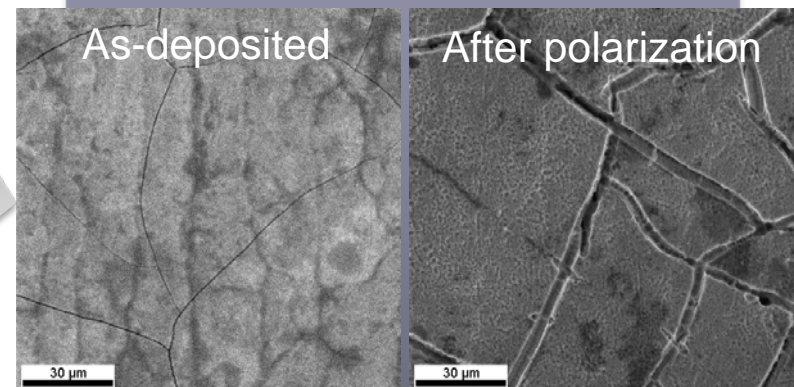
**Linear Polarization**  
**In 3.56wt% NaCl, aerated**

[1] Luis Caceres, Tomas Vargas, Leandro Herrera, Corros. Sci. 47 (2007) 3168–3184.

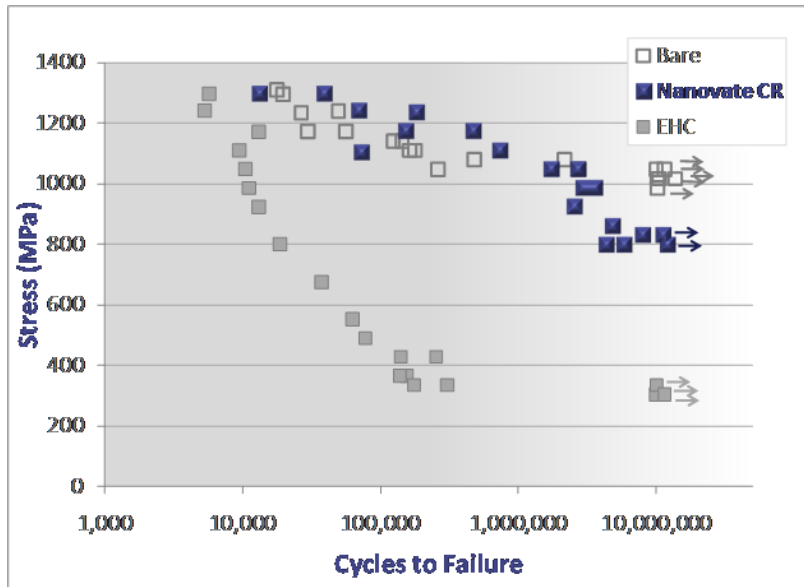
### Nanovate™ CR



### Hard Chrome



## Nanovate™ CR enhances fatigue life

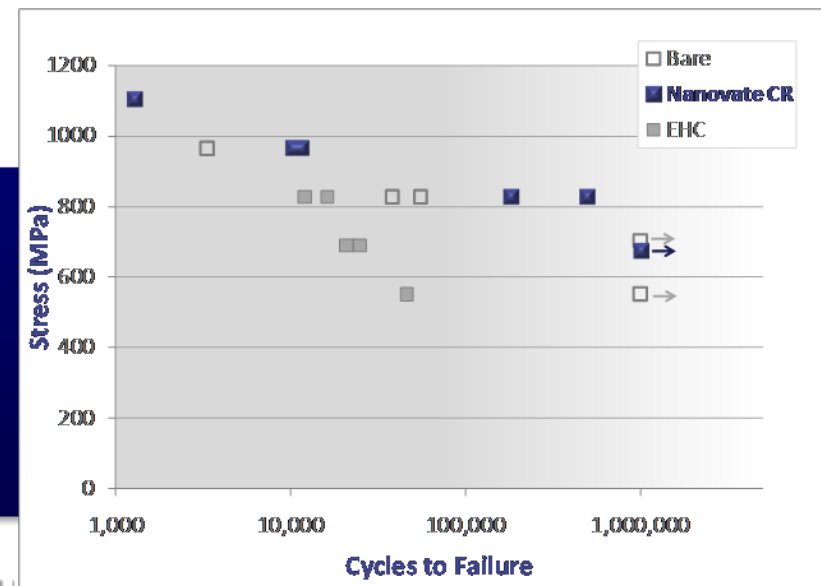


### Rotating Beam Fatigue

- 4340 substrate (UTS: 1790-1930 MPa)
- Significant credit vs. chrome
- Comparable to bare

### Axial Fatigue

- 4340 substrate (UTS: 1240-1380 MPa)
- Preliminary data
- Credit vs bare & chrome



- **FRC-SE (NAVAIR JAX)  
Dem/Val Process Line**

- 250 gallon Plating Tank (2.5'x4'x4')
- 370 gallon Activation Tank (3'x3'x6')
- Pulse Power supply (1500A Peak Current)
- Remote Controller (Dynatronix)



Dem/Val Plating Tank



Power Supply



Remote Controller



Acid/Fluoride Activation tank

- **Sample Aerospace Applications**

- OEM and rebuild/repair
- Gas turbine engines
- Actuators
- Landing gear
- Propeller hubs
- Valves
- Pistons
- Shocks



**Success Story:  
Enduro Industries**

- Commercial scale deployment of Nanovate™ CR
- Produce Nanovate™ CR-coated hydraulic actuators for fluid power



**Nanovate CR production  
plating line at Enduro  
Industries (Hannibal, MO)**



## T-45 Arresting Hook Pivot Assembly



## A/S32A-32 Aircraft Towing Tractor "Spotting Dolly" Spread Cylinder Hydraulic Rod



- Marine Corps MK48 LVS (Logistic Vehicle System) Hydraulic Cylinders
  - Reduce corrosion maintenance requirements and repair costs of vehicles
  - Test plan
    - Bench testing on carburized steel panels (in progress)
    - Accelerated corrosion testing (GM9540P)
    - Field test on MK48 vehicles



# Summary

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## Nanovate™ CR Hard Chrome Alternative

- Environmentally compliant EHC alternative
- Process compatible with existing plating infrastructure
- Reduced energy consumption, increased throughput
- Enhanced corrosion and wear
- Non-embrittling
- Improved fatigue performance vs. EHC

Diana Facchini  
Project Leader  
416-675-6266 x 236  
facchini@integran.com  
www.integran.com

